Region 10
U.S. Environmental Protection Agency

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Phase I Sediment Sampling Data Evaluation Upper Columbia River Site CERCLA RI/FS Section 6 pages 197 - 208

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SECTION 6

Summary of Findings and Sediment Data Gaps

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The 2005 Phase I sediment sampling program has produced a large body of representative data on sediment contamination in the UCR river/reservoir system. This information has been used to refine the preliminary sediment CSM. Although this Phase I study encompassed a broad-scale evaluation of sediment within the UCR, additional phases of sediment investigation will be needed to further refine the CSM and to further provide information to assess potential risks to human and ecological receptors in the UCR.

The RI/FS process is both iterative and sequential. The need for additional information will be determined as the RI/FS process progresses. This section presents a summary of the findings from the Phase I sediment sampling program. It also presents a summary of sediment data gaps identified through evaluation of the Phase I data.

6.1 Summary of Findings

6.1.1 Data Quality

The 2005 Phase I sediment sampling program data are of known quality and provide a basis for refinement of the preliminary sediment CSM. Program DQOs for targeted analytes were met with two exceptions, antimony and uranium, as described below:

- For antimony, the laboratory analytical results for 109 of the 236 transect samples were rejected during validation due to low matrix spike recoveries. Given the percentage of rejected results, the Phase I data for antimony do not provide adequate coverage for the transect sample group to allow a full assessment of its nature and extent (see Section 2.5.2.3).
- Uranium was detected in 83 of 368 sediment samples, with concentrations ranging between 4.6 and 127 mg/kg (Figure 2-28). More than 75 percent of the samples were reported as nondetects due to reporting requirements established through the CLP. However, if the laboratory-specific MDLs are considered, a significantly higher percentage of the data could be used for assessing the nature and extent of uranium (see Section 2.5.2.3). This assessment has not yet been performed.

6.1.2 Constituents of Interest Identification

The selection of COIs described in Section 4 is based on comparison of Phase I RI/FS sediment analytical results for target analytes to sets of published risk-based sediment screening levels. It should be noted that the COI selection process did not involve an assessment of risk, site-specific or otherwise, other than that done by the publisher of the screening levels. Nor did the COI selection process entail consideration of the selected published sediment screening values as ARARs. Rather, the process constituted an initial screening of the large body of sediment analytical data generated during the Phase I

sediment sampling program in order to identify chemicals or locations of possible interest. The following COIs were identified based on these comparisons:

- Metals: antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, uranium, and zinc
- Organics
  - Pesticides: 2,4-DDE, 2,4-DDT 4,4-DDD, 4,4-DDE, 4,4-DDT, and aldrin
  - PCBs: Aroclor 1016 and Aroclor 1260
  - Dioxins and furans: 2,3,7,8 TCDD toxicity equivalent (TEQ) and 14 congeners, as listed in Table 4-1
  - PAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene

6.1.3 Contaminant Sources

Known and potential sources of contaminants in UCR sediment include mining and milling operations, smelting operations, pulp and paper production, sewage treatment plants, and other industrial activities (see Section 5.1). The 2005 Phase I sediment sampling program did not identify any new COI sources. The sources of metal and organic contaminants in UCR sediments are as follows:

- Metals Sources
  - The historic discharge of water-granulated fumed slag, liquid effluent, and spills from the Cominco Smelter complex is the single largest known and documented source of metal COIs for UCR sediments. Other potential metal sources include mining and milling operations, smelting operations at the former Le Roi/Northport smelter, sewage treatment plants, and other industrial activities.
  - The source of uranium could not be determined, although the distribution is similar to other water-granulated fumed slag associated metals.
- Organics Sources
  - Pesticides: The source of pesticides could not be determined. Sediment pesticide concentrations are relatively low and have no definitive spatial pattern. Pesticides in sediment may be related to agricultural use within the large UCR watershed. The highest concentrations of pesticides were detected in beach samples collected at Columbia Beach (RM 642), possibly indicating a nearby local source or localized zone of accumulation.
  - PCBs: The source of PCBs could not be determined. Aroclor 1016 and Aroclor 1260 were each detected once at a concentration exceeding the CCT human health criteria. The detected exceedances occurred at the same sample location RM 687A1, located 13 miles downstream from Marcus Flats. This is in the general vicinity where PCBs were detected at low concentrations in bed sediment samples collected from nearby locations during previous investigations by Ecology in 1990 (Ecology, 1991) and

USEPA (E&E, 2003). The observation that detection of PCBs has been limited to the general area between RM 687 and 690 suggests the possibility of a local PCB source or a localized zone of accumulation in that area.

- PAHs: Sediment PAH concentrations are relatively low and have no definitive spatial pattern. No specific source of PAHs can be identified from the sediment data.
- Dioxins and furans: The congener 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF) is the congener with the greatest number of detects and the greatest number of exceedances of COI identification criteria. 2,3,7,8-TCDF is known to have been released from Celgar (Ecology, 1997). Celgar was identified as a source of dioxin and furan discharges to the Columbia River prior to modernization (Evergreen State College, 1993; USGS, 1994).

6.1.4 Nature and Extent of COIs in Sediment

The nature and extent of sediment contamination is generally consistent with sampling results from prior studies. Metal and organic COIs were detected throughout the UCR. Metal COIs are the primary contaminants above Marcus Flats. Metals and organics are both found below Marcus Flats and are generally associated with inorganic and organic silt-, clay- and colloid-sized material (see Section 5.4). The general distributions of water-granulated fumed slag associated metals, other metals, and organics in the UCR are illustrated in Figure 6-1. The three large graphs in Figure 6-1 depict general longitudinal distributions for the COI groups over the length of the UCR; smaller insets in the graphs depict the transverse distributions of the COI group and sample point elevations at transects located above Marcus Flats (RM 723), within Marcus Flats (RM 706), and below Marcus Flats (RM 678).

6.1.4.1 Metal Contaminants

Metal contamination within and upriver from Marcus Flats appears to be related primarily to coarse-grained water-granulated fumed slag; the metal COIs in sediment that show a strong association with the water-granulated fumed slag include antimony, arsenic, chromium, copper, iron, lead, manganese, and zinc. Elevated reporting limits for uranium in a number of samples limit the ability to make spatial distribution evaluations for this metal, although the highest detected concentrations are located above Marcus Flats.

From the evidence and observations gathered to date, the primary accumulation areas within the UCR for coarse-grained water-granulated fumed slag are the following:

- Side-bank beach and point bar areas in the upriver reaches (e.g., Black Sand Beach at RM 742; large point bar deposit at RM 738) deposited during high river flow events
- Dispersed accumulations to an unknown depth within the interstices of the coarse, cobbly sediments in the main river channel upstream of approximately RM 729 (Onion Creek)
- Localized accumulations within the original pre-reservoir river channel downstream from approximately RM 729 to approximately RM 710 (near the entrance to Marcus Flats)

- Within Marcus Flats, accumulations concentrated in the original pre-reservoir river channel

Appreciable accumulations of water-granulated fumed slag were not identified below Marcus Flats by the Phase I sediment samples. However, water-granulated fumed slag could be present, intermixed at depth with other sediment within the original pre-reservoir river channel downstream of Marcus Flats, because approximately 3 million tons were discharged from the Cominco Smelter complex prior to the construction of Grand Coulee Dam (see Section 5.1.1.2). Silt-sized or finer particles of slag could also be deposited in the lower velocity portions of the reservoir downstream from Marcus Flats along with other silt-sized and finer sediment, because approximately 1 percent or less of the slag discharged to the Columbia River is estimated to be within this size range (see Section 5.1.1.2). Silt-sized or finer particles of slag could also be present below Marcus Flats due to weathering and decrepitation processes affecting larger slag particles as described by USGS (USGS, 2005).

Metals contamination below Marcus Flats appears to be less related to coarse-grained water-granulated fumed slag and more related to either liquid effluent discharges (which may include particulate, colloidal, complexed, sorbed, or dissolved forms of metals), very fine-grained water-granulated fumed slag particles, and/or leaching and flaking of metal from the surfaces of weathered or abraded water-granulated fumed slag particles. The degree to which these three sources contribute to sediment contamination below Marcus Flats is unknown.

In general, sediment below Marcus Flats that lies at an elevation below approximately 1255 has higher metal concentrations than elevations above 1255 due to periodic washing of fines and their associated contaminants from the exposed banks and transport to lower elevations.

6.1.4.2 Organic Contaminants

Concentrations of organic contaminants within UCR sediment are generally low (see Section 5.4.2), but, where present, typically exceed the organic carbon normalized CCT human health sediment standards (see Section 4.2). No definitive spatial pattern has been identified for the organic COIs.

6.1.5 Fate and Transport of Contaminated Sediment

At the UCR-wide scale, the concentration of contaminants in UCR sediment appear to be relatively stable based on comparisons of Phase I sediment sampling results to historical sampling results. Small-scale variations in contaminant concentrations likely will occur due to seasonal changes in river flow and stage and could influence sediment transport and the redistribution and mobilization of COIs. For example, in the upriver portions of the system where river flow velocities are expected to be highest, movement of both fines (<75 um) and coarser grained sediment—including sand-sized water-granulated fumed slag—is expected to occur. Additional fate and transport findings are as follows:

- The apparent fate and transport of contaminated sediment is believed to be consistent, overall, with the mechanisms described in the A&R Document (CH2M HILL, 2004b, Section 4.4).

- Hydrodynamics and river/reservoir relationships are believed to be the dominant factors affecting distribution of sediment contaminants following construction of Grand Coulee Dam (see Section 5.2.1). However, other important factors affecting the distribution of contaminants include particle size, shape, and density; sorting of bed sediment; and riverbed morphology.
- Above approximately RM 711, sand-sized contaminants (principally water-granulated fumed slag) move longitudinally downstream, primarily via bedload transport. This sediment transport mechanism appears to become much less significant below about RM 701; below this, the major mechanisms for longitudinal transport for contaminants (as either dissolved phase, suspended particulates, or sorbed, complexed, or colloidal forms) appears to be primarily via solution transport and/or transport as suspended sediment.
- Although some water-granulated fumed slag is transported along the water surface as small, floating mats, the overall significance of this process is not understood.
- Transverse movement of contaminants (i.e., perpendicular to the flow direction of the river) is expected to occur throughout the UCR study area, predominantly due to natural erosional processes and the washing of the side banks due to seasonal changes in river flow and reservoir level fluctuations (see Section 5.5.2.1). Current reservoir and river management operations and the associated reduction in annual peak flow discharges (compared to historical conditions) are thought to reduce the potential for large-scale broadcasting of sand-sized or finer contaminated sediment into higher elevation side-bank areas.
- Downstream from Marcus Flats, transverse movement of side bank sediment to depths below about elevation 1255 appears to be limited because reservoir levels are lowered below elevation 1255 only infrequently and for short durations. Below elevation 1208 (the lowest reservoir drawdown elevation), there is likely little tendency for transverse movement of sediment-bound COIs into deeper portions of the reservoir unless there is an adjacent bank slump or some other direct physical disturbance.
- There is an insufficient quantity of comparable sediment contaminant data from prior studies to assess temporal changes.

6.2 Sediment Data Gaps

Data gaps within the sediment CSM were identified in Section 5 and are summarized below. Whether these data gaps constitute data needs for the RI/FS will be evaluated through the DQO process during future RI/FS phases. Because the RI/FS process is an iterative one, it is expected that data needs will continue to be identified as this project progresses.

6.2.1 Sources of Sediment Contamination

Data gaps pertaining to known and potential sources of contaminants in UCR sediments have been identified as follows:

- Metal COIs, including coarse-grained slag-associated metals and other metals, are documented to have been discharged into the UCR in liquid effluent from Cominco. The

chemical and physical characteristics of the metals in liquid effluent are not known based on review of available data. Additional information on the characteristics of the liquid effluent discharges may be required to better understand the nature and extent, as well as fate and transport and potential risk, of these COIs.

- Available data on liquid effluent discharges from Cominco are limited. Additional information on historic discharges from Cominco, including pre-1977 discharges, may be necessary to better understand the nature of contaminant loading to the UCR.
- Available information is limited on the chemical and physical characteristics of the water-granulated fumed slag over the period of time the material has been discharged by Cominco into the Columbia River. Additional information on these characteristics may be necessary to better understand the nature of contaminant loading to the UCR.
- The quantity and nature of water-granulated fumed slag remaining within the Columbia River above the U.S.-Canada border is not known. Additional information on this material may be necessary in order to better assess the potential for future impacts on the UCR.
- Information on current and anticipated future discharges from Cominco and associated operations and facilities, including Stoney Creek, may be necessary in order to better assess the potential for future impacts on the UCR.

6.2.2 River/Reservoir Hydraulic Relationship and Sediment Grain Size

Several data gaps are recognized to exist with respect to the overall understanding of the UCR river/reservoir hydraulics and sediment transport. These data gaps are as follows:

- Geomorphological features and environments that are present in the Columbia River floodplain (both the submerged pre-1940 floodplain and the current floodplain of the riverine portions) have not been mapped or evaluated in detail. Additional categorization and mapping of specific geomorphological features and landforms may be required to better understand the potential influence these features could have on river hydrodynamics and the distribution of COIs.
- An analysis of changes in the areal extent of exposed reservoir side-bank areas under various pool operating levels has not been conducted. Such an analysis may be important to better address possible concerns associated with wind-borne mobilization of COIs in fine grained sediment.
- Calculation of average cross-sectional flow velocity provides only a limited broad-scale understanding of sediment transport within the UCR. In order to better assess the characteristics of sediment transport in the UCR, to identify areas of active or potential sediment scour and/or deposition and the rate to which they could occur, and to provide a more detailed understanding of local-scale variations in river hydrodynamics, additional data collection and analysis may be required (e.g., high-resolution bathymetry, cross-sectional Doppler flow velocity profiling, sediment subbottom profiling, supplemental grain size analysis, hydraulic modeling, and sediment transport modeling).

- Little is known regarding the existing sediment load entering the UCR system. In particular, there is considerable uncertainty regarding the sediment flux (suspended and bedload transport) from UCR tributaries versus the Columbia River itself at the U.S.-Canada border. Sediment loading information is important for understanding sediment transport and accumulation. Additional sediment load information for the Columbia River and its major tributaries may need to be gathered to support sediment transport analysis or modeling.
- In general, a large proportion of sediment transport in riverine systems is believed to occur during episodic extreme events. The UCR reservoir is a component of a managed system in which reservoir level and river flow are largely controlled by operation of Grand Coulee Dam and dams located upstream on the Columbia River and tributaries, which greatly reduces the extremes of flow events that would otherwise strongly affect sediment transport within the UCR. Nonetheless, it is recognized that, even within the managed UCR system, extremes of flow and reservoir level may occur. The degree to which these extremes may affect sediment transport in the UCR has not been addressed by the first-pass analyses presented in this document.
- The potential role that wave action and seasonal reservoir fluctuations have on the mobilization of fine-grained sediment (possibly containing COIs) from side-bank portions of the reservoir is not well understood. Similarly, for the riverine portion of the UCR site near the U.S.-Canada border, uncertainty remains regarding the degree to which fine-grained sediment in river side-bank areas (containing variable concentrations of COIs) is scoured and eroded during high-flow and/or low-stage conditions.
- Sources or conditions that influence the spatial variations in TOC concentrations in UCR sediment are not well understood. Additional TOC sediment data may be required to better characterize TOC variations and sources and determine the role TOC plays within the fate and transport of sediment contaminants.

6.2.3 Nature and Extent of COIs in Sediment

Data gaps pertaining to the nature and extent of metal and organic COIs in UCR sediments have been identified. These data gaps are as follows:

- Insufficient comparable data are available from previous UCR sediment studies to assess temporal changes in COI concentrations. Evaluation of temporal changes in COI concentrations, although not specifically included as a DQO of the Phase I sediment sampling program, likely will be necessary as part of future RI/FS phases.
- Analytical uncertainties resulted in incomplete characterization of antimony and uranium as part of the Phase I sediment investigation. Additional antimony and uranium data may be required to more fully assess the nature, extent, and magnitude of these constituents in UCR sediment.
- The observed concentration pattern for nickel suggests a possible natural geologic source within the limits of the UCR watershed system. Additional evaluation of nickel in UCR sediments may be necessary to determine whether concentrations in UCR sediment are more attributable to natural or anthropogenic sources.

- Certain sediment samples were unattainable during the Phase I sediment investigation, especially mid-channel samples from the riverine and reservoir reaches above Marcus Flats. The absence of sediment samples from these areas limits the understanding of how sediment COIs are distributed in these portions of the UCR. Additional sediment samples may need to be collected (perhaps using different methods of sediment collection) to more fully characterize the distribution of COIs in this portion of the UCR.

- The evaluation and discussion of the findings from the Phase I sediment investigation was focused, by necessity, on a suite of COIs that served as a preliminary list of potential site contaminants. Additional analysis and evaluation of the Phase I data set (inorganics and organics) could be performed to better understand, or further refine, the nature and extent of various trace elements and COIs in UCR sediment that were not discussed in detail herein. A list of COCs will be developed during the human health and ecological risk assessments.

- Results from the Phase I sediment investigation suggest that transport of sand-sized sediment—including water-granulated fumed slag—is limited in areas downstream from Marcus Flats, whereas within Marcus Flats considerable quantities of water-granulated fumed slag are evident in the mid-channel core and surface sediment samples. Other large accumulations of slag have been documented upstream from Marcus Flats. Additional investigation of the lateral and vertical extent of water-granulated fumed slag-impacted sediment, both upstream and downstream from as well as within Marcus Flats, may be necessary to better refine the primary depositional zones for water-granulated fumed slag, and the extent over which the both the larger and smaller sized water-granulated fumed slag particles are distributed.

- The spacing of the Phase I sediment samples was established to gain a more refined and general understanding of longitudinal, transverse, and vertical distribution of COIs in sediment from throughout the UCR study area. Additional characterization samples may be needed to further refine specific areas or interest, locations of greatest sediment contamination by mass and concentration, and locations subject to scour and downstream transport.

- The various factors that influence the spatial concentration patterns for mercury and cadmium in the Marcus Flats area sediments are not well understood based on available source information, river/reservoir hydrodynamics, and the existing distribution of sediment samples. Refining the overall understanding of mercury and cadmium in UCR sediment is important to the sediment CSM and to future risk assessment efforts. Additional characterization samples from the Marcus Flats area may be necessary to better refine the nature and extent of these constituents and to identify what factors may be controlling their distribution in this area.

- Metal COIs, including coarse-grained slag-associated metals and other metals, are documented to have been discharged into the UCR in liquid effluent from Cominco. The chemical and physical characteristics of the metals in liquid effluent are not known based on review of available data. Additional information on the characteristics of the liquid effluent discharges may be required to better understand the nature and extent, as well as fate and transport and potential risk, of these COIs.

- The Phase I sediment investigation did not include a DQO related to the determination of background levels of COIs. Establishing background concentrations for selected COIs may be important, especially for purposes of risk assessment and/or when considering any possible future remedial actions.
- The Spokane River potentially has an influence on the concentrations of certain COIs that are measured in UCR sediments. However, ascribing a definitive cause/effect relationship to certain COIs without having a corresponding set of comparable data for the Spokane Arm of Lake Roosevelt limits the ability to assess this possible relationship. Additional evaluation of the Spokane River as a potential source of COIs to the lower reaches of the UCR reservoir may be necessary.
- Dioxin and furan data are limited to cores and beaches and thus provide only limited spatial coverage. Additional sampling and analysis for dioxins and furans may be necessary to provide a more complete characterization of these organic constituents in sediment throughout the UCR.
- Organic COIs have been detected in UCR sediment but have not been attributed to particular sources. Additional evaluation of organic COIs in UCR sediments may be necessary to determine whether concentrations in UCR sediment appear to be related to a specific source, or possibly are due to other causes (e.g., atmospheric deposition).

6.2.4 Fate and Transport of COIs in Sediment

Data gaps pertaining to the fate and transport of metal and organic COIs in UCR sediments have been identified and are as follows:

- Uncertainties remain with respect to the chemical processes that affect the potential remobilization of COIs that occur in association with the fine-grained sediment fraction. It is recognized that, although processes such as chemical oxidation, desorption, weathering, abrasion, dissolution, and benthic flux may be influencing the fate and transport of COIs in UCR sediment, specific details regarding these mechanisms is lacking. Investigation of such mechanisms was not a DQO of the Phase I sediment investigation program. Additional information on COI remobilization may be necessary to better understand the importance of these mechanisms on the fate and transport of COIs in UCR sediment.
- Uncertainties remain with respect to the physical and chemical processes and kinetics that affect the weathering/degradation and leaching of water-granulated fumed slag in the UCR environment. Evaluation of these processes on water-granulated fumed slag was not a DQO of the Phase I sediment investigation program; initial investigations of this process have been conducted by the USGS. Additional information on water-granulated fumed slag weathering may be necessary to better understand the importance of this process on the fate and transport of metal COIs in UCR sediment.
- Metal COIs, including coarse-grained slag-associated metals and other metals, are documented to have been discharged in to the UCR in liquid effluent from Cominco. The chemical and physical characteristics of the metals in liquid effluent is not known based on review of available data. Additional information on the characteristics of the

liquid effluent discharges may be required to better understand the fate and transport of these COIs.

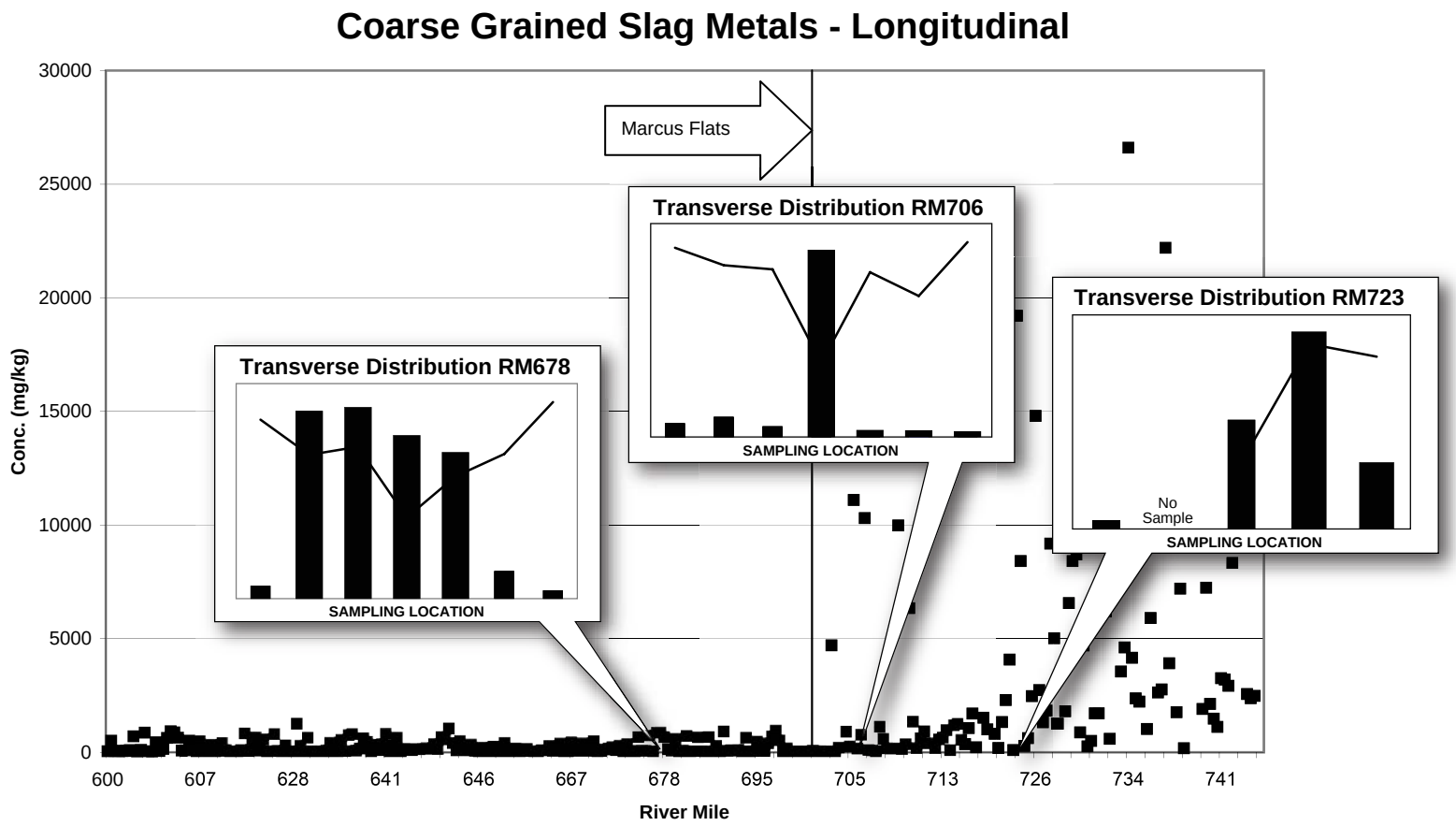
- Tributary mouth areas can be complex and dynamic due to a variety of hydraulic, chemical, and physical processes that occur in these localized environments. Information collected during the Phase I sediment investigation provided limited information on the apparent nature and extent of COIs in the immediate vicinity of major tributary mouths. Additional data collection may be required to address specific fate and transport considerations or risk assessment concerns associated with tributary mouth areas**.**

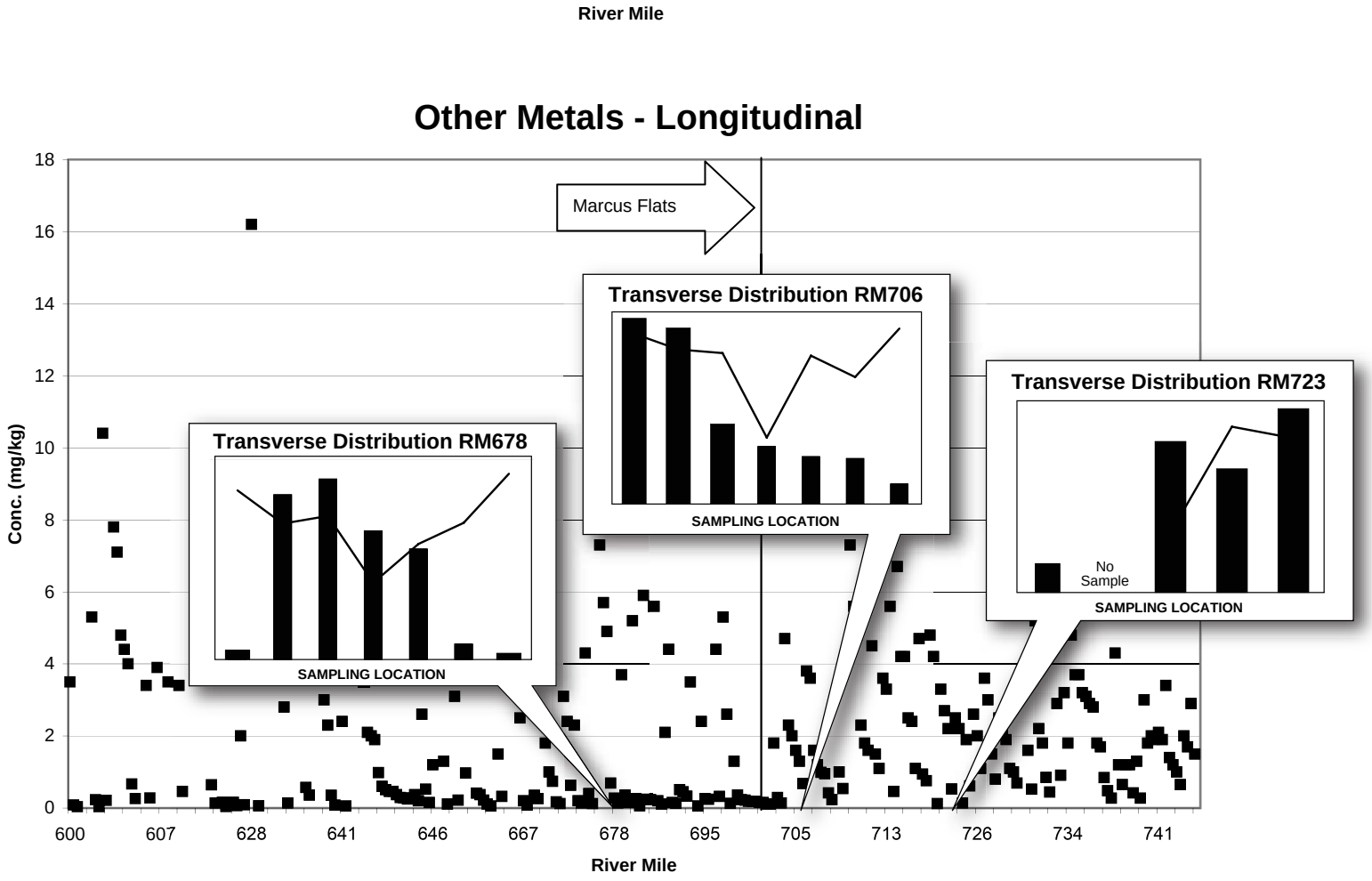
- Consistent with project DQOs, the spacing of the Phase I sediment samples was designed, at large, to provide a general understanding of longitudinal, transverse, and vertical distribution of COIs in sediment from throughout the UCR study area. Additional characterization samples may be needed to further refine locations of greatest sediment contamination by mass and concentration at a smaller scale of resolution. Similarly, if it appears that high chemical variability occurs over small lateral or vertical distances, additional investigation may be necessary to better assess local-scale variations in fate and transport processes.

- The preliminary sediment CSM discusses the potential role of liquid-phase sorption/desorption to fine-grained sediments and TOC. The Phase I investigation did not include specific DQOs that were intended to address the degree to which liquid-phase COIs are sorbed to clay minerals and/or plankton. The specific role that suspended clay minerals and/or organic debris may play in controlling the fate and transport of COIs in the UCR environment may need to be further evaluated.

- Findings from the Phase I sediment investigation suggest there may be an association between the concentration of certain COIs, TOC, and the quantity of sediment fines. Additional information on the role that TOC and fine-grained particulates have on contaminant mobility and bioavailability may be necessary.

- Little information is available on sediment deposition rates within the UCR system. Establishing sediment deposition rates at several different locations within the system may be useful for understanding variations in sediment transport and the fate and transport of COIs. Age dating of sediments may also be useful to better understand such variations in sedimentation rates and magnitudes.





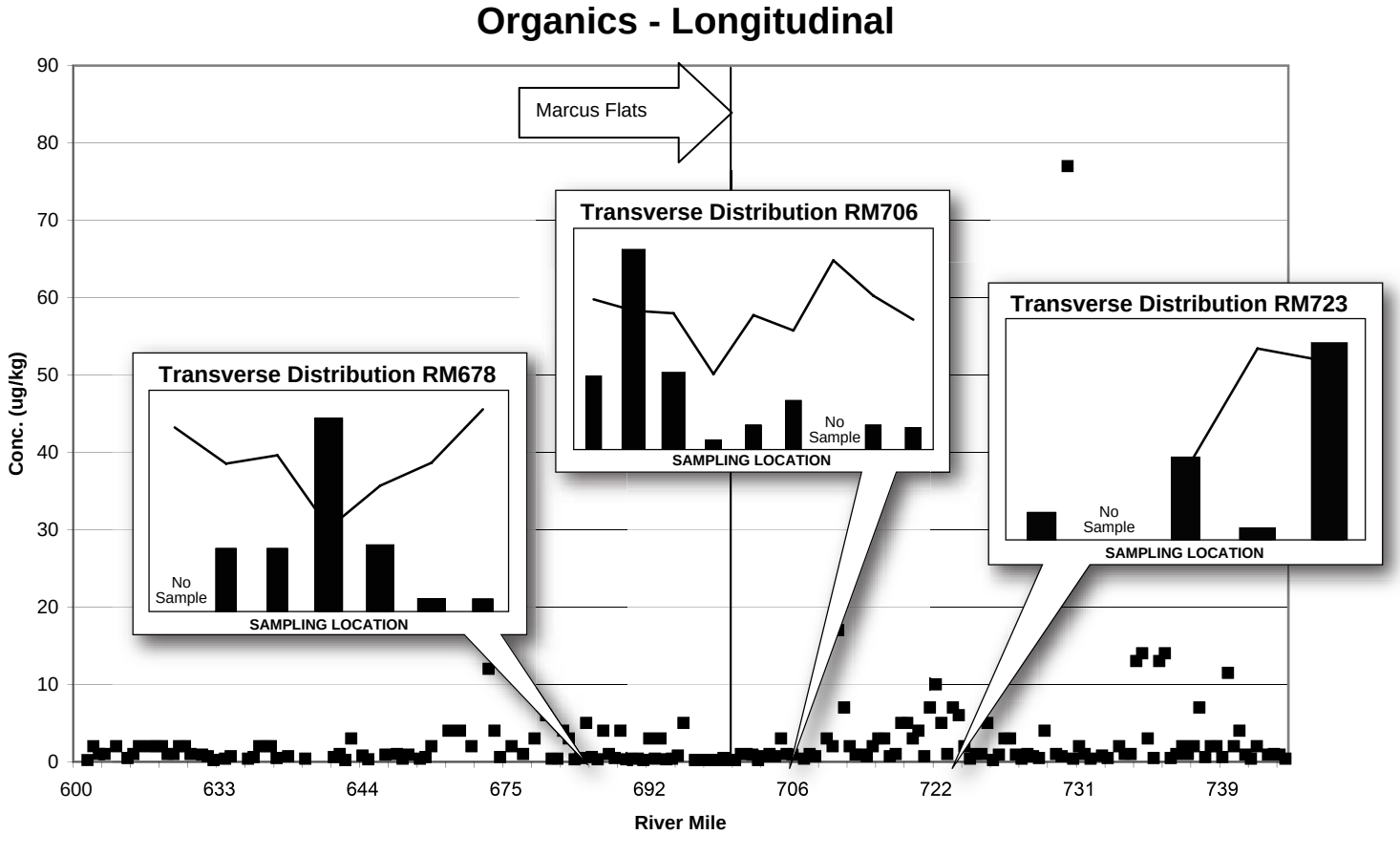


Figure 6-1
Summary of COI Distribution
Upper Columbia River RI/FS